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We derived basic equations for basic electron scattering processes in narrow band gap semiconductors. However even in the case when the relaxation time approximation can be introduced a set of cumbersome integrals has to numerically calculated for intermediate degeneracy of an electron gas which is characteristic for narrow band gap semiconductors at liquid nitrogen temperature. As to the scattering by optical phonons the standard relaxation time approximation is, in general, not applicable.

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BRIEF OUTLINE OF RESEARCH FINDINGS

We derived basic equations for basic electron scattering processes in narrow band gap semiconductors. However even in the case when the relaxation time approximation can be introduced a set of cumbersome integrals has to numerically calculated for intermediate degeneracy of an electron gas which is characteristic for narrow band gap semiconductors at liquid nitrogen temperature. As to the scattering by optical phonons the standard relaxation time approximation is , in general, not applicable.

Hence, we started from deriving an analytical equation for the polar optical phonon mobility, which is valid when the electron thermal energy is much smaller than the optical phonon energy. We also took into account the effects of the nonparabolicity which include the change of the dispersion law and the interband mixing of wave functions. We calculated the polar optical phonon mobility of the 2D-gas near insulator-semiconductor heterostructure in Metal-Insulator-Semiconductor (MIS) structure. Then we have developed simple analytical approximations for basic electron scattering processes in semiconductors at any degree of degeneracy . We have considered three most important scattering processes: by impurities, by polar optical phonon and due to piezoelectric interaction with acoustical phonons. We apply our new approach for the calculation of transport characteristics of a wide band gap semiconductor GaN which has a great potential for application in high power and optoelectronic devices. The Hall and drift mobility electrons in bulk GaN as well and in the 2D-gas at AlGaN/GaN heterointerface have been calculated . This calculation required us to develop a new analytical theory of the Hall factor for impurity scattering -- a classic problem which has attracted attention since yearly 50s. We proposed an analytical equation describing the temperature and concentration dependencies of the Hall factor. We also demonstrated that the enhanced mobility of the 2D gas in GaN is caused by an enhanced electron screening. This work is joint with APA Optics, inc., and our results are in excellent agreement with experimental data. We have also developed analytical approximations for transport parameters which will be used in device simulation. In order to perform accurate device simulation without resorting to the time consuming Monte-Carlo simulation , we used a set of phenomenological balance equations including momentum and energy balance. At first it was necessary to have accurate and simple approximations for the transport parameters. For the calculation of transport parameters in GaAs and InP Monte-Carlo simulations were performed for wide range of electric field, temperature and impurity concentration. Then we have developed analytical approximations for transport parameters as functions of temperature, electric field and energy .These approximations can be used in device simulation. These results were submitted to Silvaco, Inc. for the incorporation in their device simulation ATLAS II.

Infrared focal plane arrays of photodetectors require small pixel size with uniform response over large areas. As the detector area decreases, surface and geometrical effects become increasingly important. In particular the zero-bias resistance of the photodetector has to be calculated taking into account the lateral spreading of the flow of the minority carriers . In practical photodetector arrays the layer thickness is comparable with the diffusion length. Since the absorption coefficient is relatively large and the light is absorbed near the surface, the collection of the photogenerated carriers improves when the junction is closer to the back surface of the device , i. e. when the layer thickness is decreased. On the other hand, the spreading resistance decreases with an increase in the layer thickness. Choosing he layer thickness to be on the order of the

diffusion length is a reasonable trade-off, since at such values of the layer thickness nearly all photogenerated carriers are collected by the junction. When the layer thickness is comparable to the diffusion length, analytical treatment does not apply. We developed a simple model, which is applicable when the layer thickness, b, and the diffusion length, L, are small in comparison with the detector radius. We also derived an integral equation, which is valid for any ratios of the layer thickness, the recombination length, and the detector radius. This equation can be easily solved by standard numerical techniques.

Our new approach allowed us to calculate the Hall and drift mobility electrons in bulk GaN as well and in the 2D-gas at AlGaN/GaN heterointerface. This calculation required us to develop a new analytical theory of the Hall factor for impurity scattering -- a classic problem which has attracted attention since yearly 50s. We proposed an analytical equation describing the temperature and concentration dependencies of the Hall factor. We also demonstrated that the enhanced mobility of the 2D gas in GaN is caused by an enhanced electron screening. This work is joint with APA Optics, inc., and our results are in excellent agreement with experimental data.

In addition, the work has been done on general properties of surface electron plasma in heterostructures. We demonstrated that in typical 2D systems in compound semiconductors and even in silicon, electrons behave not as 2D-gas but rather as 2D fluid. The collective excitations of such a fluid are surface plasma waves that may become unstable under constant current conditions. This led to several new device concepts, including electronic flute, resonant and non-resonant plasma detectors, mixers, and terahertz oscillators. These devices should be able to push a three terminal device operation into a much higher frequency range than has been possible for conventional, transit time limited regimes of operation.